**AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.**
**1791 Tullie Circle, NE Atlanta, GA 30329 404-636-8400**

**TC/TG/TRG MINUTES COVER SHEET**

(Minutes of all meetings are to be distributed to all persons listed below within 60 days following the meeting.)

**TC/TG/TRG NO. TC 4.11 DATE: January 20 , 2004**
**TC/TG/TRG TITLE: Smart Building Systems**
**DATE OF MEETING: July 1 , 2003 LOCATION: Kansas City**

| Members Present | Appt | Members Absent | Appt | Ex-Officio Members and Additional Attendance |
|---|---|---|---|---|
| Les Norford, Chair (V) | 02-03 | Osman Ahmed (V) | 02-06 | Eric Adams |
| Todd Rossi, Technology Development Subc, (V) | 02-03 | Steve Blanc (V) | 99-03 | David Bornside |
| Cliff Federspiel (V) | 02-06 | Natascha Castro, Testing & Evaluation Subc, Web Master (V) | 02-04 | Daniel Choiniere |
| Rich Hackner, Program Subc. (V) | 01-05 | Arthur Dexter, International member (V) | 01-05 | Maria Corsi |
| Carlos Haiad (V) | 00-04 | Srinivas Katipamula (V) | 01-05 | Bill Healy |
| Phil Haves (V) | 01-05 | Michael Kintner-Meyer, Communications and Integration Subc (V) | 02-03 | David Holmberg |
| Agami Reddy (V) | 02-06 | John Seem (V) | 99-03 | Damian Ljungquist |
| | | | | Gene Strehlow |
| | | | | Jonathan Wright |
| | | | | Jensen Zhang |
| | | | | |
| | | **Corresponding Members** | | |
| **Corresponding Members** | | Michael Brandemuehl, CM | 99- | |
| John House, Vice Chair, Research Subc, CM | 00- | Dave Branson, CM | 01- | |
| | | Marty Burns, CM | 02- | |
| Mike Brambley, Secretary, CM | 02- | Jim Butler, CM | 02- | |
| James Braun, CM | 01- | Charles Culp, CM | 00- | |
| Barry Bridges, CM | 02- | Thomas Engbring, CM | 99- | |
| James W. Gartner, CM | 02- | Carol Lomonaco, Program Subc, CM | 00- | |
| David Kahn, CM | 00- | Ron Nelson, CM | 01- | |
| George Kelly, CM | 01- | Hung Mahn Pham, CM | 99- | |
| John Mitchell , CM | 00- | Kinga Porst, CM | 01- | |
| Robert Old, CM | 01-05 | Barry Reardon, CM | | |
| Peng Xu, CM | 02- | Glenn Remington, CM | 01- | |
| Chariti Young, CM | 96- | Pornsak Songkakul, CM | 01- | |
| | | James Winston, CM | 02- | |

(V) = voting member, Membership status as of 9/02

DISTRIBUTION:
ALL MEMBERS AND CORRESPONDING MEMBERS OF TC/TG/TRG,
TAC CHAIR: William E Murphy
TAC SECTION HEAD: Eckhard Groll
ALL COMMITTEE LIAISONS AS SHOWN ON TC/TG/TRG ROSTERS:

| | |
|---|---|
| Program: Kelly Cramm | Manager Of Technical Services: Michael Vaughn |
| Research: Sheila Hayter | Manager Of Research: William W. Seaton |
| Standards: Richard Hermans | Manager Of Standards: Claire B. Ramspeck |
| Journal/Insights: Harvey Sachs | Special Publications: Marilyn Listvan |
| TEGA: Clarles Gulledge | ALI: Alexander Boome |

ADDITIONAL DISTRIBUTION: Visitors listed above

**ASHRAE TC ACTIVITIES SHEET**

**DATE: 1 July 2003**
**TC NO. TC7.5 TC TITLE: Smart Building Systems**
**CHAIR: Les Norford VICE CHAIR: John House**

**TC Meeting Schedule**

| Location, past 12 mo. | Date | Location, next 12 mo. | Date |
|---|---|---|---|
| Chicago | 1/28/03 | Anaheim | 1/27/04 |
| Kansas City | 7/1/03 | Nashville | 6/29/04 |

**TC Subcommittees**

| Subcommittee | Chair |
|---|---|
| Technology Development | T. Rossi |
| Communications and Integration | M. Kintner-Meyer |
| Testing & Evaluation | Natascha Castro |
| Research | J. House |
| Program | R. Hackner |

**Research Projects**

1043-RP Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers

1139-RP Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment

**Long Range Research Plan (as approved by TC 4.11 at the Kansas City Annual Meeting)**

## 2003-2004 Research Plan

| Priority | Project | Contributors | Status |
|---|---|---|---|
| 1 | Field Performance Assessment of Package Equipment to Quantify the Benefits of Proper Service | Todd Rossi<br>Mark Breuker<br>Jim Braun | RTAR rejected 9/00.<br>Revised RTAR to be submitted by 8/01/01 as priority 1 RTAR for 2001.<br>Revised RTAR approved 9/01.<br>WS approved in Atlantic City 10-0-0 (CNV).<br>WS submitted to RAC 5/15/02.<br>Returned by RAC (Honolulu).<br>WS approved in Honolulu subject to minor revisions<br>WS approved by RAC in Spring 2003 (co-funding from DOE and CEC) |
| 2 | Tools for Evaluating FDD Methods for AHUs (Was "Method of Testing FDD Tools for AHUs") | John House<br>Jonathan West<br>Srinivas Katipamula<br>Phil Haves | RTAR to be submitted by 8/01/01 as TC 4.11 priority 2 RTAR for 2001.<br>RTAR approved 9/01.<br>Scope changed and RTAR re-submitted to RAC 8/02 and prioritized in Fall 2002.<br>Draft WS exists. |
| 3 | Design and Demonstration of a Self-Configuration Concept for an HVAC Control System | Michael Kintner-Meyer | RTAR submitted to RAC 8/02 and prioritized in Fall 2002.<br>Draft WS exists. |
| 4 | Fault Detection and Diagnostics for Centrifugal Chillers – Phase 3: Real-Time Implementation | Jim Braun<br>John House<br>Srinivas Katipamula | RTAR to be submitted to RAC by 8/01/03 as priority 1 RTAR for 2003. |
| 5 | Real-Time Optimal Control in a Distributed Environment | Jim Braun<br>George Kelly<br>Maria Corsi | RTAR to be submitted to RAC by 8/01/03 as priority 2 RTAR for 2003. |

| | | | |
|---|---|---|---|
| 6 | Whole-Building FDD | Les Norford | New research idea proposed in Honolulu. |
| 7 | FDD for Supermarket Refrigeration | Daniel Choinière | New research idea proposed in Honolulu. |
| 8 | Development of Tools for Assessing the Value of Demand Response Assets | Michael Kintner-Meyer | New research idea proposed in Honolulu. |

**Technical Papers from Sponsored Research**

Norford, L. K., J. A. Wright, R. Buswell, and D. Luo. 2000. "Demonstration of Fault Detection and Diagnosis Methods in a Real Building (ASHRAE 1020-RP)." ASHRAE 1020-RP Final Report.

Luo, D., L. K. Norford, S. R. Shaw, and S. B. Leeb. 2002. "Monitoring HVAC Equipment Electrical Loads from a Centralized Location - Methods and Field Test Results." ASHRAE Transactions Vol. 108(1).

Shaw, S. R., L. K. Norford, D. Luo, and S. B. Leeb. 2002. "Detection of HVAC Faults via Electrical Load Monitoring." Int. J. of HVAC&R Research 8(1):13-40

Norford, L.K., J. A. Wright, R. A. Buswell, D. Luo, C. Klaassen, and A. Suby. 2002. "Demonstration of Fault Detection and Diagnosis Methods for Air-Handling Units (ASHRAE 1020-RP)." Int. J. of HVAC&R Research 8(1):41-72

Final report for ASHRAE Research Project RP-1011, "Utility/Energy Management and Control Systems (EMCS) Communication Protocol Requirements" is available on the TC 4.11 web site.

Results from the ASHRAE Research Project RP-1139, " Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment " have been published in the January 2001 issue of HVAC Journal.

Final report for ASHRAE Research Project RP-1043, " Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers" is available on the TC 4.11 web site.

Technical paper from 1043-RP, Comstock, M.C., Braun, J.E., and Groll, E.A., "The Sensitivity of Chiller Performance to Common Faults," International Journal of Heating, Ventilating, Air-Conditioning and Refrigerating Research, Vol. 7, No. 3, pp. 263-279, 2001.

Technical paper from 1043-RP, Comstock, M.C., Braun, J.E., and Groll, E.A., "A Survey of Common Faults for Chillers," ASHRAE Transactions, Vol. 108, Pt. 1, 2002.

**TC Sponsored Symposia (past 3 years, present, planned)**

| **Title** | **Date (Given or Planned)** |
|---|---|
| Recent Results from Fault Detection and Diagnostic Research (Norford) | Atlanta, 1/01 |
| HVAC Diagnostics: Development to Implementation Part 1 (House) | Atlantic City, 1/02 |
| HVAC Diagnostics: Development to Implementation Part 2 (Dexter) | Atlantic City, 1/02 |
| FDD, Operation and Maintenance of HVAC Systems (Kelly, TC 1.4 cosponsor) | Kansas City, 6/03 |
| Automated Commissioning Tools (Corsi) | Orlando |

**TC Sponsored Seminars (past 3 years, present, planned)**

| **Title** | **Date (Given or Planned)** |
|---|---|
| Diagnostics from an Operations Perspective, Needs and Experiences (Rossi) | Atlanta, 1/01 |
| Adding New Life to Old System-Control Retrofit Case Studies (TC 1.4 lead) | Atlanta, 1/01 |

| | |
|---|---|
| Maximizing Facility Performance with Computerization and Controls (Gartner) | Cincinnati, 6/01 |
| Data Modeling for Building Operations (Kintner-Meyer) | Cincinnati, 6/01 |
| BACnet Manufacturers Association (BMA)- New role in Testing Interoperability of BACnet Systems (Newman) | Cincinnati, 6/01 |
| Wireless DDC Systems (TC 1.4, Bridges lead) | Cincinnati, 6/01 |
| Intelligent Agents - What They Can Do For You (Ahmed, TC 4.6 co-sponsor) | Honolulu, 6/02 |
| Self-Configuring Control Systems: Technology and Potential Benefits (Brambley, TC 4.6 co-sponsor) | Honolulu, 6/02 |
| Experience with Demand Responsiveness Programs (Haves, TC 4.6 co-sponsor) | Honolulu, 6/02 |
| New Issues in State of the Art DDC Systems (Atkinson, TC 1.4 co-sponsor) | Honolulu, 6/02 |
| Automated Functional Testing of HVAC Systems (Haves, TC 1.4 and 4.6 co-sponsors) | Chicago, 1/03 |
| New Issues with State-of-the-Art DDC (Atkinson, TC 1.4 and 1.5 co-sponsors) | Chicago, 1/03 |
| Wireless Sensors for Building Applications (Healy, TC 1.4 co-sponsor) | Kansas City, 6/03 |
| Improved Operations for California Buildings -Part II (Chris Scruton, co-sponsored with TC4.6) | Anaheim |
| Automated Commissioning Tools (Marie Corsi, co-sponsored with TC 9.9 and possibly TC 1.7) | Anaheim |
| FDD from an Operator's Perspective (Rossi) | Future |

**TC Sponsored Forums (past 3 years, present, planned)**

| **Title** | **Date (Given or Planned)** |
|---|---|
| Specifying Open Lonmark DDC Systems | Atlantic City, 1/02 |
| What Should ASHRAE's Role be in IFC and XML Standards (Gowri, GPC20 and TC 1.5 cosponsor) | Chicago 1/03 |
| Wireless Sensors for HVAC Systems(Brambley) | Kansas City |
| Addressing the Need for Data Modeling Beyond Building Design- What Role Should ASHRAE Play | Future |
| New Sensor Technology, Other New Technologies (Kintner-Meyer) | Future |

**TC Sponsored Public Sessions (past 3 years, present, planned): None**
**Journal Publications (past 3 years, present, planned): None**

**Minutes summary and activities sheet submitted by: Michael Brambley, TC 4.11 Secretary**

**TC 7.5 Minutes**
**Kansas City: July 1, 2003**

## Call to Order, Roll Call, Introductions

The meeting was called to order at 3:35 PM with Chairman Les Norford presiding. Minutes from the Chicago meeting were distributed.

A roll call showed an insufficient number of members present to establish a quorum. Later in the meeting (as noted later in these minutes) a quorum was established with 7 of 13 voting members present. In attendance at the meeting were Norford, Rossi, Federspiel, Hackner, Haiad, Haves, and Reddy.

Norford distributed the Agenda (the call-to-meeting letter and the agenda are in Appendix A).

## Approval of Minutes

The minutes of the last meeting were reviewed and corrections to the attendance were provided by meeting attendees. A vote was not taken because a quorum was not yet established.

## Committee Scope

The Chair read the committee scope for the benefit of all in attendance, particularly new members. (see Appendix B)

## Chair's Announcements (Norford):

Norford's announcements focused on information provided at the TC chair's breakfast hosted by TAC. The realignment of the TC sections is being finalized, with TC 4.11 slated to join section 7 in July as TC 7.5. The section is as follows:

Section 7 Building Performance

7.1 (4.12) Integrated Building Design
7.2 open
7.3 (1.7) Operation and Maintenance Management
7.4 (4.6) Building Operation Dynamics
7.5 (4.11) Smart Building Systems
7.6 (9.6) Systems Energy Utilization
7.7 (9.7) Testing and Balancing
7.8 (1.8) Owning and Operating Costs
7.9 (9.9) Building Commissioning

TAC continues to work with the Handbook Committee in an effort to best provide content that meets the needs of the membership. The re-organization of the TCs provides the new TC 7.5 a natural opportunity to develop handbook material with like-minded TCs, which the new TAC section head, Craig Wray, was asked to promote.

Richard Rooley, incoming ASHRAE President, spoke at the Chair's breakfast and emphasized the community of ASHRAE and the need to learn the language of and partner with others within and outside ASHRAE, including local BOMA and AIA chapters.

ASHRAE now offers a server with 20 MB of space for each TC/TG website. Several TC chairs asked for more space.

The ASHRAE headquarters at KC features a laptop printer station, a good idea, providing a new alternative for printing.

The ASHRAE Learning Institute (ALI) requests ideas for self-directed learning courses, professional development seminars, and short courses to be presented by ASHRAE chapters.

TC's are encouraged to have international members as both voting and corresponding members to take advantage from knowledge from other countries. Typically, TCs have up to two voting international members, but more than that is permissible and some can be corresponding members.

Conference and meeting announcements:

> 21st International Conference on Refrigeration in Washington, DC, August 17-22
> CIBSE/ASHRAE Conference Building Sustainability, Value and Profit, Edinburgh, September 24-26
> IBSE Conference, Biennial International Conference, Eindhoven, August 11-14.

ASHRAE Research Summary: ASHRAE currently has 74 projects underway. Twenty nine projects were completed in the last year. Bidders are expected to be selected for six new projects at the Kansas City meeting. Fifteen work statements had been approved prior to this meeting. Eight to ten of these may go out to bid prior to the Anaheim meeting in January. Fourteen new work statements were reviewed last Friday (no information was available yet on how those came out). TC 4.11 should be selecting a bidder in Executive Session immediately following this meeting for the "Chiller Phase 2" project.

Outgoing ASHRAE President, Don Colliver, has offered to send letters to employers thanking them for participation of members. Norford circulated sign-up forms for meeting participants to indicate interest in their employers receiving letters. He will then follow up by submitting the names for letters. Letters will come from the President's office.

Jim Gartner announced that the ASHRAE board has merged the standing committees for TEGA with Chapter Programs. The new technology transfer committee is charged with making more effective communication by the TCs with the chapters. TCs that would like to get more active with the chapters should express interest. The committee is also charged with developing a satellite broadcast on extraordinary incidents (terrorist attacks, earthquakes, etc.). The contact for this broadcast is the ASHRAE Washington, DC, office. All relevant TCs should get involved. The broadcast will be released by the end of the year. Norford said the incoming Chair will contact the Washington office.

Norford then asked for updates from the subcommittee chairs.

**Technology Development Subcommittee (Rossi)**

Todd Rossi reported that the subcommittee met on Sunday. He reported as follows:

Chiller FDD Project: The TC is considering Phase III of the chiller FDD project. Jim Braun provided a summary of the project roadmap.

John House summarized recent events with respect to Phase II of this project entitled "Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers: Part II." Highlights included that bids have been received and evaluated. He reported that the Executive Committee was scheduled to meet at the end of this TC meeting to vote on a recommendation for the contractor. Discussion followed.

Wireless Sensors: Rossi reported that wireless sensors were discussed in the subcommittee meeting. Ideas are being formulated, relevant issues identified, and potential TC actions in this area identified. He also announced that a seminar on wireless sensing sponsored by TC 4.11 would be held the next day and all were encouraged to attend. Bill Healy provided a brief description of the seminar.

Real-time Optimal Control in a Distributed Environment: Todd Rossi reported that most of the subcommittee time was spent discussing this research topic. An RTAR has been prepared by Jim Braun, Maria Corsi and George Kelly. The project is expected to be co-sponsored by TC 4.6 (which will become TC 7.4). Jim provided a summary of the topic and the RTAR. The scope was reduced since the last meeting to primarily a scoping study, development of concepts for applications to HVAC, and recommendations for follow-on work. This would likely be the first phase of possibly three.

The minutes of the subcommittee meeting are in Appendix C.

**Communications and Integration Subcommittee (Peng Xu reported for Michael Kintner-Meyer)**

Peng Xu reported most of the subcommittee meeting was devoted to discussing the work statement on self-configuring systems. Key suggestions at the subcommittee meeting included:

- the work statement should be more specific
- the approach could be used for augmented testing

Peng asked for additional volunteers to help with this SOW.

John House reported that he mentioned this topic to TC 1.4 and that this committee should follow up by giving the next draft to TC 1.4 for review. Peng agreed to do this for the next

meeting.

Les Norford added that there had been some discussion on the possibility that there be an experimental component to this work.

The minutes of the subcommittee meeting are in Appendix D.

**Testing and Evaluation Subcommittee (John House reporting for Natascha Castro)**

John reported that the entire subcommittee meeting was devoted to discussing the work statement Tools for Evaluating Fault Detection and Diagnostic Methods for Air Handling Units, for which John is the lead author.

John distributed a limited number of copies of the work statement and then provided a summary of the scope, deliverables (including real data sets that could be used for testing FDD tools), and the tasks.

A number of comments were provided in the subcommittee meeting, and John summarized them and key revisions made to the work statement in response to the comments. He reported that the level of effort would probably need to increase above $100K because of the need for the contractor to perform experimental validation.

Discussion followed regarding: potential points to terminate project if not progressing satisfactorily, clarification of the final deliverable, and how much the cost would increase. In response, John identified points in the project where PMSC approval is needed to proceed to the next step. For clarifying of the outcome of the project, John described the final deliverable as a dynamic simulation model that can simulate proper as well as faulty behavior plus the data used to validate the model. Regarding cost, John was not ready to suggest an amount yet.

Phil Haves reported that Director approval is required for funding amounts greater than $120K, adding another hurdle, not an insurmountable one but yet another hurdle.

John proposed to clean up the work statement in the next couple weeks and then distribute for review and vote. Comments need to be provided back to John by August 1. He will then decide how to proceed based on the review comments.

The minutes of the subcommittee meeting are in Appendix E.

**Research Subcommittee (House)**

John House reported that the committee needed to develop a long-term research plan at this meeting. He distributed copies of the June 2002 Research Plan and led the committee through the list and proposed revisions to it.

**A Quorum was established at 4:45. The attendance list as recorded at the front of these minutes records attendance as recorded at the time of establishing the quorum.**

After discussion of the proposed research plan, the following motion was made:

**Motion 1: Accept the Research Plan as prioritized by John House. (Hackner moved, Haiad seconded)**

Discussion followed.

Agami Reddy proposed a project on Documenting the Benefits of Intelligence in Buildings. This prompted discussion on the need or lack of need to define "intelligent buildings" as well as a potential seminar on "Vision of What Smart Buildings Are or Could Be." John House proposed recording in these minutes the interest expressed in this topic.

Norford called the vote on Motion 1.
**Outcome of Vote on Motion 1:**
**Unanimously approved, 7-0-0, Chair voting.**
**Motion passed.**

John House raised the question of how the committee wants to use its two potential RTAR slots. Currently, the committee only has one RTAR fully prepared entitled "Real-Time Opt. Control in a Distributed Environment." If the committee is satisfied with the vision for the chiller FDD phase III, it could be submitted as a second RTAR. Discussion followed. The consensus of the committee was to delay a vote on chiller FDD Phase III until the RTAR was finalized.

The schedule for approval of a second RTAR was presented as follows:

RTARs must be submitted by August 1
RTARs to committee members – July 15
Committee vote completed – July 14 - 21

**Motion 2: Submit the RTAR on Real-Time Optimal Control in a Distributed Environment as first priority. (Haves moved, Rossi seconded)**

Discussion followed. Motion 2 was amended by friendly amendment as follows:

**Motion 2 (as amended): Submit the RTAR on Real-Time Optimal Control in a Distributed Environment prioritized according to the Research Plan."**
**Unanimously approved, 7-0-0, Chair voting.**
**Motion passed.**

The TC 4.11 Research Plan as amended and approved by the committee is attached as Appendix G.

**Program Subcommittee (Hackner)**
Rich Hackner reported on the Kansas City program:

Symposium: "FDD, Operation and Maintenance of HVAC Systems," George Kelly, Chair, Monday, 10:15 – 12:15

Seminar: "Wireless Sensors for Building Applications," Bill Healy, Chair, Wednesday, 8:00 – 10:00

Rich then reviewed the program input from the other subcommittees for Anaheim and beyond. After discussion, Rich Hackner made the following motion:

**Motion 3: Accept the program plan for Anaheim in order of priority as follows:**

1. **Seminar: "Improved Operations for California Buildings -Part II," Chair: TBD, Chris Scruton (co-sponsored with TC4.6)**
2. **Seminar: Automated Commissioning Tools Chair: Maria Corsi (co-sponsored with TC 9.9 and possibly 1.7)**
3. **Seminar: "In 2010: What Will a Building Have to Say? ….and Who Will Listen?" Chair: Phil Haves**

**(Hackner moved, Haves seconded)**
**Approved by unanimous vote. (7-0-0, chair voting)**
**Motion passed.**

Les Norford agreed that the chair will endorse the following co-sponsorships:

1. Improved Operation for California Buildings – Part 1, sponsored by TC 4.6 and cosponsored by TC 1.4.
2. Flight Simulator for Buildings – sponsored by TC 4.6
3. State-of-the-Art Issues for DDC Systems, Parts A & B, sponsored by TC 1.4

Programs as approved by ASHRAE are tabulated at the beginning of these minutes.

**Old Business**
No old business.

**New business**
Roster changes: Les Norford reported that 5 members will be rolling off the roster as voting members and becoming corresponding members: Michael Kintner-Meyer, Todd Rossi, Steve Blanc, John Seem, and Les Norford.

New Voting members to be appointed: John House, Mike Brandemeuhl, Jim Braun, Jim Gartner, and Jon Wright as International Member

New Corresponding Members to be appointed: Andy Price, Darrell Massey, Maria Corsi, Michael Pouchak, Keith Temple, Mingsheng Liu, Xiaohui Zhou.

Officers after the Kansas City meeting will be:

Chair: John House
Vice Chair and Research: Mike Brambley
Secretary: Todd Rossi
Program: Rich Hackner
Handbook: Les Norford
Testing & Evaluation and Web Master: Natascha Castro

Technology Development: Srinivas Katipamula
Communications and Integration: Peng Xu

Les thanked and the outgoing officers and subcommittee chairs for their service and those incoming for their willingness to serve.

John House as incoming Chair thanked Les Norford for a job very well done as Chair and his service over many years (Les was the original secretary) as did the committee by a rousing round of applause.

**Motion 4: Approve the minutes from Chicago as corrected (Haiad moved, Hackner seconded)**
**Unanimously approved by vote (7-0-0, Chair voting)**
**Motion passed.**

**The meeting adjourned at 5:40 pm.**

**Executive session to be held immediately following adjournment to select a contractor for 1275-RP Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II. The executive session was held and bids for 1275-RP were discussed. A vote for selection of the contractor was delayed because only six voting members were present for the executive session, one short of a quorum. A vote will be taken instead via email ballot.**

## Appendices

A. Call to Meeting and Agenda
B. Scope and Organization
C. Technology Development Subcommittee Report
D. Communications and Integration Subcommittee Report
E. Testing and Evaluation Subcommittee Report
F. TC4.11 Research Subcommittee meeting/Planning Session
G. Research Plan and Activities
H. List of Subcommittee and Committee Meeting Attendees

# Appendix A.
# Call to Meeting and Agenda

**ASHRAE** American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

1791 Tullie Circle, NE, Atlanta, Georgia 30329-2305 404-636-8400 | Fax 404-321-5478

Reply to: Les Norford
Room 5-418
MIT
77 Mass. Ave.
Cambridge, MA 02139
lnorford@mit.edu

June 20, 2003

Dear TC 4.11 Member, International Member, or Corresponding Member:

The **TC** on Smart Building Systems will meet in the Westin Hotel and its subcommittees will meet in the Hyatt, both in Kansas City, Missouri, according to the following schedule:

| | | | | |
|---|---|---|---|---|
| TC 4.11 | Tech. Development | Sunday (6/29) | 3:00-3:45p | H New York B (BR) |
| TC 4.11 | Comm. & Integration | Sunday (6/29) | 3:45-4:30p | H New York B (BR) |
| TC 4.11 | Testing & Evaluation | Sunday (6/29) | 4:30-5:15p | H New York B (BR) |
| TC 4.11 | Research | Sunday (6/29) | 5:15-6:00p | H New York B (BR) |
| **TC 4.11** | **Smart Building Systems** | **Tuesday (**7/1**)** | **3:30-6:00p** | **W Pershing E (BR)** |

The BR designation refers to the ballroom level in both hotels.

TC 4.11 is sponsoring or co-sponsoring the following program sessions:

Symposium KC-03-08: FDD, Operation and Maintenance of HVAC Systems (TC 4.11 sponsor; TC1.7 co-sponsor)
Monday, June 30, 2003, 10:15 AM – 12:15 PM, Hyatt New York B (BR) Chair: George Kelly

Seminar 43: Wireless Sensors for Building Applications (TC 4.11 sponsor, TC 1.4 co-sponsor)
Wednesday, July 1, 2003: 8:00 – 10:00 AM, Hyatt New York B (BR) Chair: Bill Healy

Attached is a draft agenda for the full TC 4.11 committee. I hope to see you all in Kansas City.

Les Norford
Chairman, TC 4.11

# ASHRAE TC 4.11, Smart Building Systems
# 2003 Annual Meeting
# Westin Crown Center
# Kansas City, MO

AGENDA

**Location:** **Pershing E (Ballroom Level)**
**Date:** **Tuesday, July 1, 2003**
**Time:** **3:30 - 6:00 p.m.**

1. Roll call and introductions

2. Approval of Minutes from Chicago

3. Announcements

4. Technology Development Subcommittee (Todd Rossi)

5. Communications and Integration Subcommittee (Michael Kintner-Meyer)
   - Work statement for "Design and Demonstration of a Self-Configuration Concept for an HVAC Control System" (prioritized RTAR!)

6. Testing and Evaluation Subcommittee (John House for Natascha Castro)
   - Work statement for "Method of Test of AHU FDD Tools" (prioritized RTAR!)

7. Research (John House)
   - Long-range research plan for 2004

8. Program Subcommittee (Rich Hackner for Carol Lomonaco)
   - Plans for Anaheim (January 24-28, 2004) and Nashville (June 26-30, 2004)

9. Old business

10. New business
    - Roster for coming year

11. Adjournment

12. Executive session for voting members
    - Selection of contractor for 1275-TRP, "Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II"

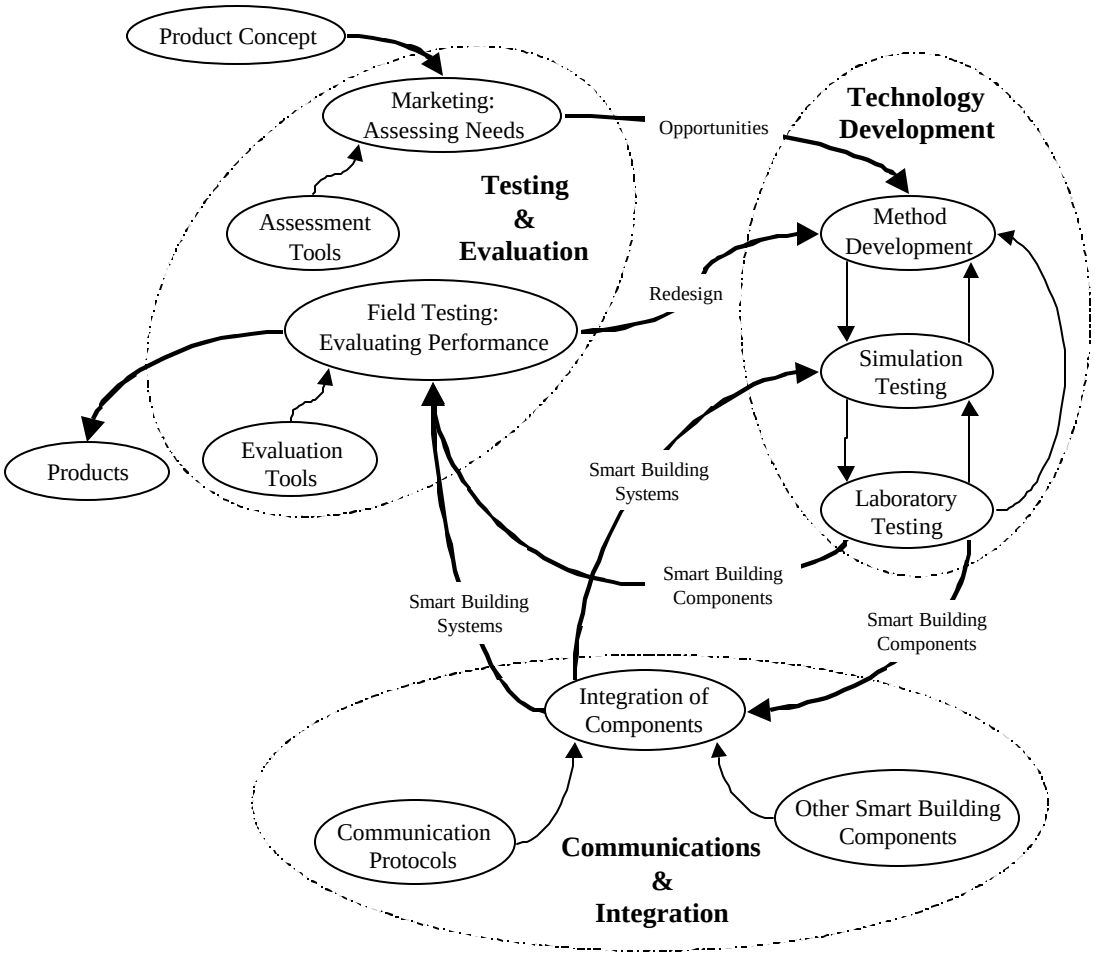
# Appendix B.
# TC 4.11, Smart Building Systems Scope and Organization

**Revised July 1, 2001**

**Overall Committee Scope**

The Technical Committee on Smart Building Systems (SBS), TC 4.11, is concerned with the development and evaluation of technologies that could enable the widespread application of smart building systems. "Smart" buildings should take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. This implies integration of building services such as HVAC, fire, security, and transportation; the automation of many of the operation and maintenance functions traditionally performed by humans; and the interaction with outside service providers such as utilities, energy providers, and aggregators. Currently, three subcommittees form the backbone of the TC's activities: technology development, communications and integration, and testing and evaluation. The scope and activities of these subcommittees loosely follow the product development process as depicted in following flow chart and as defined in the following sections.

## Smart Building System Development Process



## Technology Development Subcommittee

### Scope

The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building technologies such as (but not restricted to) automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and self-configuring control. The primary outcome of research endorsed by this subcommittee is expected to be data and models that enable development of the technologies and comprehensive methods that are the basis of the technologies. An integral part of the development process is simulation and laboratory testing. Proposed designs must be tested and modified prior to field evaluation or integration with other smart building components.

### Vision

The ever-increasing speed of organizational changes of the occupants in today's buildings demand greater flexibility of the building structure and the building automation system to respond to these changes. Furthermore, smart building systems offer the promise of dramatically improved building performance (e.g. comfort, reliability, and energy efficiency) and lower operating cost.

HVAC equipment automated commissioning, performance monitoring, fault detection and diagnostic, and optimal service scheduling technology directs service personnel to fix equipment problems causing poor comfort, reliability, and/or energy efficiency during different stages in building life cycles. Compared to the tools available today, these technologies are more sensitive to significant performance degradations, they are more aware of the entire building performance picture, and they help accomplish service tasks quicker.

Plug-and-play or self-configuring control systems are critical technologies needed to make buildings more flexible and to reduce the labor and expertise needed to install and maintain building automation systems. Self-configuring controllers understand their role in the building system. They are aware of the presence of other devices in the building and how they relate and interrelate with them to collectively provide building services. This high level of functionality is provided by highly skilled people at great cost today. When these people are freed for these tasks and costs are reduced, sophisticated building automation systems will become even more wide spread and the people will move on to even higher level tasks leading toward finely tuned and optimally performing buildings.

### Research Agenda

To accomplish these broad goals, the subcommittee is focusing its near-term effort in the following directions:

1. Fault detection and diagnostic (FDD) technology focused on HVAC components like refrigeration cycles (including chillers, direct expansion cooling, and refrigeration) and air handing units.
2. Technologies supporting equipment FDD including smart sensor systems.
3. Self-configuring control systems

## Research Projects

The sections below list ongoing (o) and planned (p) research related to the subcommittee's technology development goals. The subcommittee has no completed (c) or rejected (r) research projects. The studies are also shown on a timeline provided as a separate document.

- o **1043-RP Fault Detection & Diagnostic Requirements & Evaluation Tools for Chillers** – Purdue University was provided a no cost extension until the expected completion date on 6/31/01.

- o **1139-RP Development and Comparison of On-line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment** – Drexel University was provided a no cost extension until the expected completion date on 8/31/01.

- p **Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II** - Approved in Minneapolis and will submit to RAC AFTER Phase I (1043-RP) is completed. RTAR approved 9/00.

- p **Smart Sensor Systems for Reducing Measurement Errors in AC Systems** - One page description exists. A two page version is being discussed and revised.

- p **Self-configuring Control Systems** – RTAR+ document under development for Cincinnati.

There are three phases associated with this the chiller fault detection project. The first phase is an ongoing project (1043-RP) where the important faults are being considered and the appropriate sensors will be identified. In addition, a model for simulating chiller behavior is being developed that can be used to evaluate FDD performance for the different faults. The second phase is a planned research project where the FDD methods will be developed, implemented, and evaluated through simulation. This phase will produce a comparison of alternative FDD methods and recommendations for real-time implementation. Finally, the third phase will involve the real-time implementation and evaluation of FDD methods within the laboratory and the field. It is hoped that by the end of the third phase, an algorithm will be specified for incorporation within commercial products.

## Communications and Integration Subcommittee

### Objective

The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services within buildings, among buildings, or with an outside third party. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. Another aspect of this work deals with the technical issues, challenges, and opportunities of integrating building systems to utilize synergies among the system components to achieve high performance building operation and highly productive work and living environments.

### Addressing the Need for Innovative Building Automation Communications Systems and Services

Key to the high-performance operation and maintenance of a smart building system is the communication among various building system components that enables innovative control, monitoring and diagnostics concepts. The ever-increasing speed of organizational changes of the occupants in today's buildings demand greater flexibility of the building structure and the building automation system to respond to these changes. This will require highly flexible building automation system and a communication infrastructure to support the flexibility demanded.

Wireless sensors and control systems are emerging for building automation applications that provide a great opportunity to support and expand innovative and flexible control concepts to allow personalized and localized buildings control. As personalized and localized controls become reality, the number of sensors and control points in a building will grow significantly. This increase in sensor and control points will require a communication infrastructure that can re-configure itself to quickly establish connectivity to the added devices to the entire network. Plug-and-Play concepts are necessary for the rapid deployment of new sensors and control equipment with minimal or no set-up time.

The convergence of data and building automation networks will enable innovative remote building monitoring and control services. The need to reduce cost for the building operation will drive innovation for building remote monitoring, diagnostic, and control concepts. New building cooling, heating, and power technology and distributed power concepts will enable buildings to become zero-buyers of electricity or even net producers of electric power, whenever there is an economic incentive. To evaluate the economics of the trade-off between on-site electricity production and buying electric power from the service provider requires instant communications to the electricity markets to receive the hourly or sub-hourly changing price information. With these new technologies in place, the defining lines between the supply and demand sectors become increasingly blurred. Advanced load management strategies will seek optimal operation and dispatching of heating, cooling, and power system not only within the framework of a single building but also in a campus setting including many buildings. To engage in these new services, constant interactions among the energy consuming and producing

must be in place. This will require information protocols and standards to support these services over wide-area networks.

## Addressing the Need for Integration of Building Systems

The subcommittee addresses integration issues at three levels:

1. Integration of existing building automation functions (e.g., HVAC, lighting, fire alarm, safety and security systems)
2. Integration of advanced automated fault detection and diagnostic methods and tools into existing HVAC control systems
3. Integration of different automated fault detection and diagnostic tools to enhance each other's functionality and effectiveness.

Integration of existing building automation functions: Building control system in the past have been developed and deployed independently from each other to address a specific building need. HVAC, lighting, fire alarm, and safety systems emerged in their specific industries with a set of standards and safety requirements. To fully utilize cost savings opportunities the building control systems will need to be integrated into one building automation system. Integration will support not only the use of common communication infrastructure but also seek synergetic interactions that provide enhanced functionality and value added.

Integration of advanced automated fault detection and diagnostic tools into existing HVAC controls: With the transition of automated fault detection and diagnostics tools from the research to the demonstration and deployment stage, the new tools need to be integrated into existing HVAC equipment control or building automation systems to share sensor and equipment information for the diagnosis.

Integration of different advanced fault detection and diagnostics tools into larger diagnostics systems. As more fault detection and diagnostics tools for HVAC equipment are being developed, it becomes increasingly important to harmonize the results of each diagnostic component in order to resolve discrepancies in the diagnosis and to seek internal corroboration and mutual substantiation of the same underlying problem. As the complexity of the HVAC fault detection and diagnostic system grows, it will be essential to maintain internal consistency among different diagnostic tools.

## Near-Term Research Agenda of the Subcommittee:

To satisfy the science and technology needs mentioned above, the subcommittee will work on the following research topics:

1. Establish communication protocols that support automated data exchanges between service providers and buildings automation system to enhance energy efficiency, high performance of equipment operations and cost savings in buildings.
2. Promote plug-and-play and self-configuration concepts to avoid set-up problems of HVAC control systems.
3. Research the use of wireless sensors and controls for building operations and the integration into existing wired controls infrastructures.
4. Research integration opportunities to enhance the value of each single controls and

diagnostics component.

The section below lists ongoing (o), planned (p), completed (c) and rejected (r) research related to the topics above.

**(c) 1011-RP Utility/EMCS Communication Protocol Requirements –** completed in summer 1999. The primary objectives of research project 1011-RP were: 1) to identify potential new information services that utilities or electricity suppliers are likely to offer to their customers, 2) to determine the communication and data requirements to establish these services, and 3) to develop data object models that support interoperability for the implementation of the services.

**(p) Prototyping and Field Testing of ASHRAE's Utility Consumer Interface Models (UCIM) –** A work statement has been written. This research is an extension of the completed 1011-RP project. ASHRAE proposes a project for prototyping and testing a set of selected information services defined in research project 1011-RP. The project focuses on the prototyping and testing of information services under lab conditions in which the communicating parties are simulated. Co-sponsorship by SSPC 135 is sought.

**(p) Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic (FDD) Systems** – A work statement has been developed. The proposed research will identify conditions in which two or more fault detection and diagnostic systems of may find disagreeing conclusions for the same underlying system faults. The research will identify solutions for resolving the discrepancies in the diagnostics provided by multiple fault detection and diagnostic systems.

**(p) Self-Configuration of HVAC Control Networks –** RTAR is being developed. The proposed research will describe novel self-configuration concepts used in data networking and personal computer technologies and analyze their applicability to HVAC control networks. Self-configuration methods in personal computer technologies have been proven to significantly reduce the set-up time and set-up errors. It is expected that similar advantages can be realized for when installing complex HVAC control networks in large buildings.

## Testing and Evaluation Subcommittee

### Objective

The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the benefits (market potential) and performance of smart building technologies such as fault detection and diagnostics, automated commissioning, self-configuring systems, etc. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system benefits and performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools. The sections below describe the goals of the subcommittee in more detail and list ongoing (o), planned (p), completed (c) and rejected (r) research related to these goals.

### Assessing the Benefits of Smart Building Technologies

Research related to assessing the benefits of smart building technology can help define and justify research on such technology by establishing how (and by how much) the performance of existing technology can be improved. Successful studies of this nature can lay the groundwork for acceptance of new technology by end-users. To be successful and to gain support from ASHRAE, studies should be targeted at existing technology that is known to have performance problems. Furthermore, proposed studies should have a clear procedure and set of metrics (or at least such procedures and metrics should be perceivable at the start of the research) that will enable performance to be quantified in an objective manner (e.g., energy savings, time savings, etc.). In some cases a study may include demonstrations of prototype tools that can improve performance, while in other cases the study may be limited to measuring the performance of an existing technology, as new technology does not yet exist.

The status of studies related to assessing the benefits of smart building technology is summarized below. The studies are also shown on a timeline provided as a separate document.

1 **Integrated Control of Building Services** – RTAR was rejected by RAC and dropped from consideration by TC 4.11

1 **Field Performance Assessment of Packaged Equipment to Quantify the Need for Monitoring, FDD and Continuous Commissioning** – RTAR was rejected by RAC in the Fall of 2000 – a new version of the work statement is under development

Note that the second study cited above deals with field performance assessments of HVAC equipment. The outcome of this study should help establish the need for automated FDD and continuous commissioning. Studies aimed at field performance assessments of other equipment (e.g., chillers, fan coil units) may also be merited. At present, no research aimed at assessing the benefits of smart building technology have been identified for the focus areas of interconnectivity/interoperability and self-configuring systems. A proposed study in the area of integrated controls, services and facilities was rejected by RAC.

### Assessing the Performance of Smart Building Technologies

Research related to assessing the performance of smart building technology is intended to produce data sets, metrics, protocols, etc. for quantifying performance, and/or to demonstrate

and test specific smart building technology in pre-commercial stages of development. Successful studies will lead to tools that can be used to test the performance of smart building technology throughout its development cycle. Demonstration studies will help establish the potential of smart building technology while also identifying possible deficiencies in the demonstrated technology.

The status of studies related to assessing the performance of smart building technology is summarized below and on the timeline of the accompanying document.

1 **Demonstration of FDD Methods in a Real Building (1020-RP)** – completed 2/00

1 **Prototyping and Field Testing of Utility – Consumer Information Services** – championed by TC 4.11 Communication and Integration Subcommittee

2 **Method of Testing FDD Tools for AHU's** – existing work statement needs revision

3 **Evaluation and Assessment of FDD for Centrifugal Chillers – Phase III** – Phase II of this work is being championed by TC4.11 Technology Development Subcommittee and has not been initiated yet.

Note that the second study listed above is being championed by the Communication and Integration Subcommittee of TC 4.11; however, the testing work is closely related to the goals of this subcommittee. At present, no research aimed at assessing the performance of smart building technology have been identified for the focus areas of integrated controls, services, and facilities and self-configuring systems.

# Appendix C.
# TC4.11 Technology Development Subcommittee Meeting

**Technology Development Subcommittee**
June 29, 2003

Todd Rossi reviewed the status of the chiller FDD research. The first phase (1043-RP) consisted of: 1) identification of the most important faults for centrifugal chillers based upon frequency of service and costs; 2) development of a database of chiller performance for normal operation and with faults at different levels of severity; and 3) development of a transient chiller model that can predict the effects of faults on performance. The second phase (1275-TRP) is just starting and will involve evaluation of different FDD methods using the data and the simulation model developed in first phase and evaluation procedures to be developed in second phase. John House and Les Norford informed about the status of the PES and the selection of a contractor. A vote will be taken at the main committee meeting to recommend a contractor.

Rossi reviewed topics discussed the meeting in Chicago. One of the topics involved examining research related to self-organizing wireless sensors. Rossi asked if there is a role for ASHRAE in this area? George Kelly indicated they are being used in military applications. Carlos Haiad suggested applications for power monitoring. Norford mentioned an article by Tom Hartman in a recent ASHRAE Journal that discussed using wireless sensors for clusters of offices that might ordinarily have a single wired thermostat. The logic for organizing decisions based on these sensors is needed. Rossi asked if this was related to the RTAR "Real-Time Optimal Control in a Distributed Environment." That project involves coordinating distributed local intelligence at the supervisory level. House asked how self-configuring control systems differs from self-organizing wireless sensors. Bob Old indicated that self-organizing really entails the routing of information. There is no intelligence about their application.

The next topic of discussion was an RTAR that Jim Braun is developing. Braun passed out the RTAR titled "Real-Time Optimal Control in a Distributed Environment" and led a discussion of the project. The proposed project is the first phase of a multiple-phase project that would examine how intelligent agents have been used in other fields and identify proposed "concepts" and "protocols" for providing distributed optimization in HVAC applications that could be tested in the next phase. Hierarchical FDD could also be addressed by this same type of structure. The deliverable would be a white paper. Rossi, Norford and Mike Pouchak agreed to assist Braun and Kelly with a work statement on this topic.

Program Ideas: Forum: "Self-Configuring Sensors" Michael Kintner-Meyer
Symposium: "Future Intelligent Control Systems: They are Here Today"

Minutes by John House

# Appendix D.
# TC4.11 Communications and Integration Subcommittee Meeting

TC 4.11 Communications/Integration Subcommittee
June 29, 2003 (KC Meeting)
Notes by: Rich Hackner for Peng Xu

- Work statement Distributed: Design and Testing of a Self-configuration Concept for HVAC Control System
    a. Plug and Play idea applied to HVAC control systems
    b. Simplify setup process
    c. Currently has a priority ranking by RAC
    d. Coordinate with 1.4 ? Peng to follow-up
    e. Benefit to ASHRAE? Or Industry? ASHRAE being critical about how research can benefit ASHRAE membership
    f. Sensor type, sensor location and sensor association with other sensors are key
    g. Need to include the aspect of perturbations needed to identify sensor type and location
    h. Possible deliverables
        i. Suite of perturbations to use
        ii. Automated test procedures
    i. Next steps
        i. Tighten work scope
        ii. Define in detail the installation/commissioning process currently used
        iii. Define specific problem areas
        iv. Define how the research will address the issue(s)
    j. Re-draft to be available for Anaheim
        i. Peng with help from Bob Old and Les Norford

# Appendix E.
# TC4.11 Testing and Evaluation Subcommittee Meeting

**ASHRAE TC4.11 Testing and Evaluation Subcommittee Meeting Minutes**
**6/29/03 – Kansas City**

**John House introduced his WS on "Tools for Evaluating AHU FDD Methods".**

- We had a discussion around how the validation will take place.
- John House: Data from 1020 is available… Is this enough?
- Phil H: Concern from 1020 about how realistic fault implementation was. Consider introducing real buildings. Find problems and either test them on site or replace and take to lab and characterize (high cost recognized).
- Phil: Rework to bring out validation tasks more. This looks like primarily a simulation project. Concern about selling this WS up the chain if it is too much simulation.
- John Wright: In addition to introducing sensor faults, we should consider expected sensor uncertainty.
- John H… asks what specifically can we add to tighten up the validation step.
- This follows the template for the chiller project. Consider how the validation was done there.
- We discussed the cost and duration of the project. If we add more aggressive validation the cost goes up. Jim mentioned the chiller project was under-funded.
- **Les: Ready to vote on Tuesday with minor amount of work. Need to add a few good sentences to bolster the validation step.**
- Phil H: Validation at component and system level should occur. Add a sentence to the WS referring to this.
- Situations like reverse exhaust flow… the model must be able do this and check. This is behavior that only happens when faults occur and a simulation for this use must do this well.
- Les suggested that $100K is too small. Asked Jim Braun for input based on his experience in the chiller project. Jim: Hard to answer question. Chiller FDD was hard and expensive (e.g. tear down chiller to implement condenser fouling fault, model started more from scratch) and this project may not be a close analogy.
- Daniel C: Put simulation results in a database?
- Jim B: Envision doing all these faults at different levels? John: Yes, at least two levels (small and should be found).
- Carlos: Are we going to validate the whole thing? Sensor, actuators, dampers? John: Yes. IEC test facility would be good because it is set up for testing. Data are available from NIST/CEC project… make available to all?
- George: Other facilities and data: Colorado and Annex work exists.
- Phil: Important to figure out what data are available. The more it is, the lower the cost.
- **John: I will sort out what data are available. What is covered by the available data sets.**

- **George: NIST data is ok to use.**
- John W: Simulation should be able to implement the fault on a realistic time scale.
- Phil: Add a “time scale” parameter to the model.
- Les: Need more time to do all this. No vote on Tuesday. Email ballot or wait until next meeting. Want feedback.
- Jim B: Is coil fouling an important fault? Phil: Yes. John: Challenge to implement. **We agreed to add coil fouling to the list.**
- Les: Wait until next time. Make sure it is ready and rock solid next meeting. Phil, Les, and John to get together at this meeting and work out as much as possible. Maybe this meeting? See what gets done.
- We agreed that no one else needs to provide input to see if we can bring it together by Tuesday. John, Les, and Phil’s effort is adequate.

Program

- George: Annex 40 results ready to report? Shoot for symposium for Orlando and seminar for Anaheim (“Commissioning tools and techniques or Functional testing”). Talk to 9.9 - cosponsor. Maria to chair – she will finalize the title.

Minutes by Todd Rossi.

# Appendix F.
# TC4.11 Research Subcommittee meeting/Planning Session

## No subcommittee minutes for Kansas City.

# Appendix G.
# TC 4.11 Smart Building Systems
# Research Plan and Activities
**July 2000**

**Research Objectives:** The long-term goal of TC 4.11 is to conduct research on topics that will lead to the development and application of "smart" building systems. "Smart" buildings of the future will take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. A smart building would most likely have fully integrated control of building services such as HVAC, fire, security, and transportation. Integrated systems would reduce initial costs and could be "supervised" so as to meet the primary objectives of comfort, safety, and performance at minimum operating cost. In addition, the integration of the hardware and software for operation and monitoring of equipment would lead to reductions in support staff needs and improved equipment reliability. Further cost reductions and reliability improvements would be possible through the integration of automated techniques for detection and diagnosis of equipment faults. Ultimately, "smart" building systems could facilitate the use of "remote" support staff that operates, monitors, and maintains a number of different buildings from a centralized location. At this higher level, a smart building might communicate and inter-operate with other smart buildings for the purpose of load aggregation and centralized control and with outside service providers, such as utilities, energy providers, aggregators, and newly developing companies providing fault detection, automated commissioning, optimization, and other innovative services. In addition to the savings in operating costs associated with "smart" buildings, other benefits include energy conservation and enhanced occupant safety and comfort.

Three subcommittees form the backbone of the TC's activities: Technology Development, Communications and Integration, and Testing and Evaluation. The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building technologies such as automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and optimal control. The primary outcome of research endorsed by this subcommittee is expected to be data and models that enable development of the technologies and comprehensive methods that are the basis of the technologies. The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the benefits (market potential) and performance of smart building technologies. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system benefits and performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools.

Current TC 4.11 research includes projects in many of these areas. The evaluation of

communication protocol requirements between utilities and energy management systems was addressed in the recently completed research project 1011-RP. Fault detection and diagnostics (FDD) is being considered for a number of different HVAC applications. Demonstration of the performance and benefits of current FDD approaches for air handling systems was performed as part of the recently completed research project 1020-RP. Tools for enabling the assessment of FDD methods for chillers are being developed in 1043-RP, while the development of on-line training techniques for model-based FDD methods is being carried out in 1139-RP for vapor compression equipment.

**Revised 7/1/03 at the Kansas City meeting**

# TC 4.11, Smart Building Systems
## Research Plan and Activities
July 2003

Current Research Projects
None

## 2003-2004 Research Plan

| Priority | Project | Contributors | Status |
|---|---|---|---|
| 1 | Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning | Todd Rossi<br>Mark Breuker<br>Jim Braun | RTAR rejected 9/00.<br>Revised RTAR to be submitted by 8/01/01 as priority 1 RTAR for 2001.<br>Revised RTAR approved 9/01.<br>WS approved in Atlantic City 10-0-0 (CNV).<br>WS submitted to RAC 5/15/02.<br>Returned by RAC (Honolulu).<br>WS approved in Honolulu subject to minor revisions<br>WS approved by RAC in Spring 2003 (co-funding from DOE and CEC) |
| 2 | Tools for Evaluating FDD Methods for AHUs (Was "Method of Testing FDD Tools for AHUs") | John House<br>Jonathan West<br>Srinivas Katipamula<br>Phil Haves | RTAR to be submitted by 8/01/01 as TC 4.11 priority 2 RTAR for 2001.<br>RTAR approved 9/01.<br>Scope changed and RTAR re-submitted to RAC 8/02 and prioritized in Fall 2002.<br>Draft WS exists. |
| 3 | Design and Demonstration of a Self-Configuration Concept for an HVAC Control System | Michael Kintner-Meyer | RTAR submitted to RAC 8/02 and prioritized in Fall 2002.<br>Draft WS exists. |
| 4 | Fault Detection and Diagnostics for Centrifugal Chillers – Phase 3: Real-Time Implementation | Jim Braun<br>John House<br>Srinivas Katipamula | RTAR to be submitted to RAC by 8/01/03 as priority 1 RTAR for 2003. |
| 5 | Real-Time Optimal Control in a Distributed Environment | Jim Braun<br>George Kelly<br>Maria Corsi | RTAR to be submitted to RAC by 8/01/03 as priority 2 RTAR for 2003. |
| 6 | Whole-Building FDD | Les Norford | New research idea proposed in Honolulu. |
| 7 | FDD for Supermarket Refrigeration | Daniel Choinière | New research idea proposed in Honolulu. |
| 8 | Development of Tools for Assessing the Value of Demand Response Assets | Michael Kintner-Meyer | New research idea proposed in Honolulu. |

### Non-Prioritized Research Topics

- Prototyping and Field Testing of Utility-Consumer Information Services – Michael Kintner-Meyer and Marty Burns
- Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems – Michael Brambley
- Smart Sensor Systems for Reducing Bias Errors in the Measurement of Air Temperatures and Flows in Air-handling Units

# Appendix H.
# List of Subcommittee and Committee Attendees

## Kansas City: June 29 & July 1, 2003

| | Main Committee | Technology Development | Communications & Integration | Testing & Evaluation | Research |
|---|---|---|---|---|---|
| **Voting Members** | | | | | |
| Osman Ahmed (V) | | | | | |
| Steve Blanc, (V) | | | | | |
| Natascha Castro, Secretary, Web Master (V) | | | | | |
| Arthur Dexter, International member (V) | | | | | |
| Cliff Federspiel (V) | X | X | | | |
| Rich Hackner, (V) | X | X | X | X | X |
| Carlos Haiad, (V) | X | X | X | X | X |
| Phil Haves, (V) | X | X | X | X | X |
| Srinivas Katipamula (V) | | | | | |
| Michael Kintner-Meyer, Communications and Integration Subc (V) | | | | | |
| Les Norford, Chair (V) | X | X | X | X | X |
| Agami Reddy, CM | X | X | X | X | X |
| Todd Rossi, Fault Detection Diagnostics Subc, (V) | X | X | X | X | X |
| John Seem, (V) | | | | | |
| | | | | | |
| **Non-Voting Members** | | | | | |
| Eric Adams | X | | | | |
| Peter Armstrong | | | | | |
| Don Aumann | | | | | |
| David Bornside | X | | | | |
| Mike Brambley, Testing and Evaluation Subc, CM | X | | | | |
| Michael Brandemuehl, CM | | | | | |
| Dave Branson, CM | | | | | |
| James Braun, CM | X | X | X | X | X |
| Mark Breuker | | | | | |
| Barry Bridges, CM | X | | | | |
| Marty Burns,CM | | | | | |
| Jim Butler, CM | | X | | | |
| Par Carling | | | | | |
| Daniel Choiniere | X | X | X | X | X |
| Christian Christiansen | | | | | |
| Maria Corsi | X | X | X | X | X |
| Charles Culp, CM | | | | | |
| Jon Douglas | | | | | |

| | Main Committee | Technology Development | Communications & Integration | Testing & Evaluation | Research |
|---|---|---|---|---|---|
| Andy Drysdale | | | | | |
| Chris Early | | | | | |
| Thomas Engbring, CM | | | | | |
| Paul Francisco | | | | | |
| Theo Frutiger | | | | | |
| James W. Gartner, CM | X | | | | |
| Brent Griffith | | | | | |
| Peter Gruber | | | | | |
| David Hansen | | | | | |
| Bill Healy | x | | | | |
| Kirstin Heinemeier | | | | | |
| Gregor Henze | | | | | |
| David Holmberg | X | | | | |
| John House, Vice Chair, Research Subc, CM | | | | | |
| David Kahn, CM | X | | | | |
| George Kelly, CM | X | X | X | X | X |
| Richard Kelso | | | | | |
| Hofu Kiu | | | | | |
| Curtis Klaassen | | | | | |
| Erin Kruse | | | | | |
| Damian Ljungquist | X | | | | |
| Carol Lomonaco, , CM Program Subc | | | | | |
| Haorong Li | | X | | | |
| Mingsheng Liu | | | | | |
| Tor Malmstron | | | | | |
| Rodney Martin | | | | | |
| Darrell Massie | | | | | |
| John Mitchell , CM | X | | | | |
| Ron Nelson, CM | | | | | |
| Zach Obert | | | | | |
| Robert Old, CM | X | X | X | X | X |
| Hung Mahn Pham, CM | | | | | |
| Kinga Porst, CM | | | | | |
| Michael Pouchak | | X | X | X | X |
| Andrew Price | | | | | |
| Barry Reardon, CM | | | | | |
| Paul Reimer | | | | | |
| Glenn Remington, CM | | | | | |
| Tim Salsbury | | | | | |
| Jeffrey Schein | | X | X | X | X |
| Chris Scruton | | | | | |
| Virgil Seribo | | | | | |
| David Shipley | | | | | |
| Vernon Smith | | X | X | X | X |

| | Main Committee | Technology Development | Communications & Integration | Testing & Evaluation | Research |
|---|---|---|---|---|---|
| Pornsak Songkakul, CM | | X | X | | |
| Gene Strehlow | x | | | | |
| Keith Temple | | X | X | X | X |
| Jean Christopher Visier | | | | | |
| Jonathan West | | | | | |
| James Winston, CM | | | | | |
| Jonathan Wright | X | X | X | X | X |
| Peng Xu, CM | X | X | X | X | X |
| Chariti Young, CM | X | | | | |
| Jensen Zhang | X | | | | |
| Song Zhang | | | | | |
| Xiaohui Zhou | | | | | |
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